DESCRIPTION

OF AN

ENGINE

FOR

DIVIDING STRAIT LINES

ON

MATHEMATICAL INSTRUMENTS.

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EXPERIENCE having evinced the great utility of the engine for graduating circles, it encouraged me to attempt a ſimilar method, whereby lines of equal parts, ſines, tangents, ſecants, &c. might be divided with equal eaſe and correctneſs.

By the engine hereafter deſcribed, any line of equal parts, &c. may be divided without an error of the $\frac{1}{4000}$th part of an inch; and, as this can be done by any indifferent perſon, and ſo very expeditiouſly, its uſes for dividing all ſorts of navigation ſcales, ſectors, &c. muſt be obvious, eſpecially when it is conſidered that from the incorrectneſs of the preſent method of dividing, theſe valuable inſtruments are of leſs uſe than they might be.

This engine conſiſts of a ſtrong plate of braſs, moveable on two edges of an iron frame. To facilitate its motion, the friction is conſiderably diminiſhed by the application of three rollers to the under-ſide of the plate; the iron frame is ſupported on a ſtrong mahogany ſtand.

One edge of the braſs plate is ratched or cut into teeth, of which there are exactly twenty in an inch, and it is moved along the iron frame by an endleſs ſcrew, having exactly the ſame number of threads in an inch; theſe threads fit into the teeth on the braſs plate. Each revolution of the endleſs ſcrew round its axis will move the plate $\frac{5}{100}$ of an inch along the iron frame.

A ſmall wheel is fixed on one end of the ſcrew, having its circumference divided into 50 parts, which are again ſub-divided into five parts by a vernier; therefore, when the ſcrew is turned on its axis one of the primary diviſions, the plate will be moved $\frac{1}{1000}$ of an inch along the iron frame; if the ſcrew be turned to the coincidence of one diviſion on the vernier, the plate will be moved $\frac{2}{10000}$ of an inch, and ſo of the reſt: and the line on the plate to be divided, which terminates the ſpaces moved by the braſs plate, may be drawn on it, or on any inſtrument faſtened on the plate, with the greateſt accuracy, by a point or tracer fixed in a proper frame, whereby it has a rectilinear motion, without any lateral ſhake.

Sometimes it may be neceſſary to lay down lines on inſtruments which are not commenſurable with Engliſh inches; ſuch as are the feet, inches, &c. of moſt other countries: this is done by inclining the line to be divided to make an angle with the direction of motion of the plate, by an apparatus to be deſcribed hereafter; if the tracer be ſet to draw lines at right angles to the direction of motion, or to the ſide of the plate, then the line to be divided will be as much longer than the ſpace the plate has moved, as the ſecant of the angle of inclination is longer than the radius: but if the tracer be ſet to draw lines at right angles to the line to be divided, then diviſions on that line will be ſhorter

than

than the ſpace the plate has moved along the iron frame, as much as the co-ſine of the angle of inclination is ſhorter than the radius.

Fig 1. repreſents a plan of the dividing engine.

Fig. 2. an elevation.

Fig. 3. a ſection on the line A B. And,

Fig. 4. a ſection on the line D E.

Fig. 5. the underſide of the plate A repreſented in fig. the 1ſt.

[Note, Like parts are marked with the ſame letter in each of the figures.]

A repreſents a ſtrong braſs plate, twenty-ſeven inches long, four inches broad, and $\frac{7}{10}$ inch thick; worked exceedingly flat, and of the ſame thickneſs throughout, with its two edges exactly parallel. Fig. 1ſt.

B is a ſtrong iron frame, forty-eight inches long, having two edges (a and b) riſing half an inch above its ſurface; theſe two edges are made very ſtraight, and in the ſame plane; the inſide of the edge (a) is alſo made as ſtraight as poſſible.

The plate A ſlides on the two edges of the iron frame; beneath it are two ſprings (c c) each faſtened at the extreme ends to the plate A, by the ſcrews (ſ); at the other end of each ſpring is a roller (e) of tempered ſteel, turning on an axis in theſe ſprings; there is alſo a third roller (d) of tempered ſteel, let into the iron frame near where the threads of the endleſs ſcrew act; this roller hath a long axis, one end turning in the iron frame at (g) and the other in the lever (h); this lever turns on a center at (i) and with it the roller (d) may be raiſed, or depreſſed, by turning Fig. 5th. Fig. 3d. Fig. 2d. and 3d.

ing the capſtan head ſcrew (o) which preſſes on a ſtrong ſpring.

The uſe of theſe rollers is to diminiſh the friction of the plate A when moving on the iron frame B; for this purpoſe the ſtrength of the ſprings is regulated by turning the two ſcrews (n n) and of the roller (d) by the capſtan head ſcrew (o) till the weight of the plate A be very nearly carried on theſe rollers.

C is the endleſs ſcrew, which is of tempered ſteel, and has its pivots formed in the ſhape of two fruſtums of cones joining each other at their ſmaller end by a cylinder, as ſhewn in the deſcription of the circular engine, page 5th, vid. Fig. 5, plate the 3d of that work. Theſe pivots turn in half holes of the ſame form in the pieces of braſs D D, which are firmly ſcrewed to the iron frame; the half holes are kept together by the ſcrews (m m) which may be tightened at any time to prevent the endleſs ſcrew from ſhaking.

Fig. 2d.

On one end of the ſcrew arbor is a wheel (h) having its circumference divided into 50 parts, and numbered at every tenth diviſion with 1, 2, to 5; and theſe diviſions are again ſub-divided into five parts by the vernier (t).

Fig. 1ſt.

Fig. 5th.

G G repreſents two frames of ſteel, each of theſe frames turn on centers (k) faſtened to the under-ſide of the plate A, and equi-diſtant from the edge of it. In each frame is a roller (y) of tempered ſteel, turned very concentric to their pivots, and exactly of the ſame diameter. The frames G G are connected together by the braſs plate E, which turns on a ſtud in each frame; the ſtuds muſt be at equal diſtances from the centers (k) on

on which the frames turn, and the diſtance between the holes in the plate E in which the ſtuds act, muſt be the ſame with the diſtance between the centers (k) ſo that the plate E may always move parallel to itſelf, and that the circumference of the rollers may be always equi-diſtant from that edge of the plate A which is intended to be ratched. This apparatus ſerves to preſs the edge of the plate A with a motion parallel to itſelf, againſt the threads of the endleſs ſcrew.

On the end of the plate A is a ſpring of tempered ſteel, which acts as a bent lever. The ſpring end of this lever has a ketch which paſſes under the head of the ſtud (l) that is on the end of the connecting piece E. While the other end of the lever is preſſed gradually down towards the plate A, by turning the finger ſcrew F, the connecting piece E is drawn forward, ſo that the ſteel rollers preſſing againſt the edge (a) of the iron frame, may force the ſide of the plate againſt the endleſs ſcrew. Fig. 1ſt. and 2d.

Then having two ſcrews of tempered ſteel exactly of the ſame diameter, and number of threads, viz. twenty in an inch, one of theſe ſcrews was notched croſs the threads, ſo as to cut in the manner of a ſaw; this ſcrew was put in the half holes in the pieces D D: on the oppoſite end of the ſcrew arbor to that whereon the wheel is, there is attached a long rod, of ſuch length, that the winch on the end of it by which the rod and endleſs ſcrew are turned round, may be clear of the iron frame. Fig. 2d.

Z is a narrow ſlip of braſs, having its edges exactly parallel, which is ſcrewed on the plate A, and ſteady-pinned. Fig. 1ſt.

The edge of this ſlip is parallel to the edge of the plate A; a diſtance of 25,6 inches was ſet off on a line on the ſlip parallel

to

to its edge; this diſtance was biſected continually, till the diſtance between each biſection was $\frac{1}{10}$ of an inch.

A braſs cock was faſtened to the iron frame, which paſſing over the endleſs ſcrew, applied itſelf to the ſlip on the braſs plate A, a ſmall ſilver wire was ſtretched acroſs a hole of half an inch diameter in the end of the cock. The coincidence of the biſections with this wire was examined, by a ſmall magnifier in a braſs tube fixed exactly over it.

The plate A being on the iron frame, the biſection marked (1) towards the right hand was ſet to coincide with the wire, and the diviſion numbered 50 on the wheel, was ſet to the firſt diviſion on the nonius.

The plate A was then preſſed againſt the endleſs ſcrew, by turning the finger ſcrew F; then, by means of the winch, the endleſs ſcrew was turned towards the left ſixteen revolutions, till the biſection marked (0) was brought to the wire; this done the plate was detached from the endleſs ſcrew, by unturning the finger ſcrew F, and the diviſion numbered 2 was ſet to coincide with the wire, the diviſion 50 on the wheel being previouſly ſet to its index; and the edge of the plate was preſſed againſt the ſcrew by turning the finger ſcrew F; then by means of the winch the endleſs ſcrew was again turned round its axis 16 revolutions towards the left hand, till the biſection (1) was brought to coincide with the wire; the plate was again detached as before, and the biſection marked (3) was ſet to coincide with the wire, and in this manner the edge of the plate was ratched from end to end three or four times, till the threads had made a good impreſſion, which afterwards was ratched from end to end without ever

ever disengaging the plate from the screw, till the teeth were entirely finished.

The notched endless screw, with the rod and winch, were then removed, and the plane screw was put in its place; having the divided wheel on one end of the screw arbor, and two sets of ratchet wheels on the other end. These sets are each composed of three wheels, having teeth round their circumference; one in each set hath 32 teeth, another 48, and the third 50; these two sets being one for turning the screw, and the other for stopping it, they have for this purpose their ratchet teeth cut in opposite directions.

I represents a cylinder of brass, having on one end two steel rings (a and b) with their edges that are towards each other cut into ratchet teeth; these teeth are cut in contrary directions, so as to fit into each other; on one of these rings is an index, and the other hath its teeth numbered with 10, 20, up to 50: the other end of the cylinder is made hollow, and contains one of the sets of ratchet wheels. There are two slits opposite each other pierced through the hollowed part of the cylinder W; in each of these slits is a click turning on an axis, and is pressed into the teeth of the ratchet wheel by a small spring; the clicks may be moved along their axis, so as to catch in any one of the three ratchet wheels, and may be fastened at that place, by tightening the small screw (s). Fig. 1st. and 2d.

The cylinder I, with the clicks, &c. turns on a steel axis (x) firmly attached to the piece K, and in a line with the axis of the endless screw. Motion is given to this cylinder round its axis by a piece of cat-gut, which hath one end fastened to the ratchet ring (b); and the other end, after passing four or five times Fig. 4th. Fig. 2d. and 4th. Fig. 1st. 2d. and 4th.

times round the cylinder, is faſtened to a treadle, and on preſſing the treadle downward the clicks (s) catch in the teeth of one of the ratchet-wheels, by which means the cylinder I, together with the endleſs ſcrew, are turned round their axis, which moves the plate along the iron frame, and at ſame time winds up the ſpiral ſpring (u); on releaſing the treadle the ſpring (u) unbends itſelf, the clicks quit the ratchet wheel, and leave the endleſs ſcrew at reſt, while the cylinder I turns in an oppoſite direction, and raiſes the treadle to where it was before.

Fig. 2d.

Fig. 4th.

Fig. 2d. and 4th.

V is a ſmall ſquare bar of ſteel having both its extremities cylindric; theſe cylinders move in holes lined with hardened ſteel, one in the piece D, and the other in the piece K; this bar carries three different pieces which are of tempered ſteel; the middle one (t) is made to lie in the interval between the threads of the ſcrew cut on the cylinder, and paſſes nearly half round its circumference; it is kept in the threads by a ſpring (e) which preſſes on a piece (q) ſcrewed to the iron frame; this piece being attached to the bar (v) by the ſcrew (p) turning the cylinder I on its axis, will give a longitudinal motion to the bar V.

Fig. 2d.

The upper end of the piece (f) is formed into a hook, and may be ſet to catch in the teeth of any of the ratchet wheels, and then faſtened to the bar (v) by the ſcrew (i); towards the other end of the bar is a piece (j) which ſerves to ſtop the cylinder in turning back, ſo as to limit the number of revolutions or parts; it is faſtened to any required place on the bar (v) by the finger ſcrew (ſ).

When the engine is uſed, the treadle is preſſed downward, which by means of the cat-gut ſtring turns the cylinder I round

Fig. 4th.

its axis and the piece (t) moves along the thread, till a ſtud (r)

on

on the cylinder ſtriking on the top of the curved piece (t) bends the ſpring (e) till that piece reſts on the piece (q); by bending this ſpring the ſquare bar is turned a little on its axis, and pulls the hook (f) into the teeth on the ratchet wheel R. Then releaſing the treadle, the ſpiral ſpring turns back the cylinder, till the piece (j) is brought under the ſtop on the ratchet ring (b). Fig. 2d.

The parts of a revolution are regulated by ſetting the number required on the ratched ring (*b*) to the index on the fixed ring (*a*); each of the teeth anſwers to a motion of $\frac{1}{1000}$ of an inch of the plate A; and the number of revolutions, each of which moves the plate A $\frac{1}{100}$ inch, is regulated by ſetting the piece (j) on the bar. Fig. 1ſt. and 2d.

L repreſents the ſteel frame in which the tracer is fixed; this frame turns between the conical points of two ſcrews (*n n*) of tempered ſteel, which are ſcrewed in the frame Q; there are alſo two ſimilar ſcrews in the ſame frame at (*m m*); the points of theſe ſcrews, which are alſo of tempered ſteel, turn in conical holes in the piece P; by means of this parallel motion, the tracing point, by which the diviſions are cut, will always deſcribe the ſame line, without any lateral bending; the tracer is put in the hole in the axis (b) and is fixed there by tightening the four ſcrews (*f*) which preſſes the piece (c) againſt the flat part of the axis. Fig. 1ſt. and 3d. Fig. 2d. Fig. 2d. Fig. 2d. and 3d. Fig. 1ſt.

This axis, which hath its pivots formed in double cones, turns between the half holes at (d) and may be fixed when the tracer is ſet to any required inclination by tightening the ſcrews (s). Fig. 1ſt. and 3d.

Fig. 6th. S is a braſs ruler, having its edges very ſtraight and parallel; it hath two thin pieces of ſteel (g) attached to it, which turn on joints at (*b*) exactly equi-diſtant from the edges of the ruler; the interval between the pieces (g g) is exactly the ſame with the width of the ſteel frame L; there are angular notches on the lower edge of the pieces (g) ſimilar and equi-diſtant from their centers, ſo that when any two correſponding notches are put on the ſcrews (*n n*) between the frames Q and L, the ſcrews being on that part made cylindric, and both of the ſame diameter, then the edge of the ruler will always be at right angles to a line drawn by the tracer.

Fig. 1ſt. and 2d.

The ruler S, in this manner attached to the cutting frame, may be ſet parallel or to any required inclination with the edge of the plate A, by turning the handle T, which moves the piece P with the cutting frame and ruler on the center (*x*) may be fixed there by tightening the nut (p).

Fig. 1ſt. and 2d.

Fig. 2d.

Fig. 1ſt. From a center (*f*) on the plate (A) are drawn two circular arcs; the outer one is divided into degrees, and numbered from 1 to 9, each degree is again ſub-divided into ſix parts, or every ten minutes; the inner circle is divided in the proportion that the co-ſines of the angles of inclination with the edge of the plate A, bears to the radius, ſuppoſing the radius 10,000, and the diviſions are numbered every 10th with 10, 20 to 140: but the uſe of this apparatus may be, perhaps, better underſtood by an example.

Fig. 1ſt. Let it be required to divide a line of the length of $9\frac{999}{1000}$, into the ſame number of diviſions, and in the ſame manner as if it were 10 inches long. Put the ruler S to the cutting frame L, and turn the handle T till the ſame edge of the ruler cuts the center

center (y) and the firſt diviſion from the O of the inner arc, then ſcrew the inſtrument to be divided firmly on the plate A, ſo that the line to be divided may be parallel to the edge of the ruler, which may be now removed; when the plate has moved 10 inches in its own direction, the whole length of the diviſions on the line divided will only be $9\frac{999}{1000}$ inches.

The Deſcription of the Engine for Cutting the Screw of the Dividing Engine.

THE exactneſs of the above deſcribed engine depends very much on the correctneſs of the endleſs ſcrew, which here is required to have ſome properties that were not abſolutely neceſſary in the endleſs ſcrew for the circular engine. In that, as there were but a few threads of the endleſs ſcrew engaged in the teeth of the wheel, it only required that thoſe threads ſhould have an equal inclination to the axis of the ſcrew; but in this engine, where the whole length of the ſcrew is engaged in the teeth of the moveable plate, it is neceſſary alſo that the diſtance between the threads ſhould be the ſame throughout the whole length of the ſcrew: this is effected by the ſcrew engine hereafter deſcribed:

Fig. 7. repreſents the plan;

Fig. 8. The elevation; and,

Fig. 9. A ſection on the line: the ſame letter refers to the ſame part in each of the figures.

A repreſents a ſtrong circular plate of braſs, having its edge ratched by the method deſcribed in page 7th of the Deſcription of the Circular Engine; on its center is firmly fixed the pulley B by Fig. 7th. 8th, and 9th.

by four ſcrews, a groove is turned on the cylindric part of the pulley, perfectly concentric to the plate A.

Fig. 8th. and 9th.

C is a ſteel axis two feet long, terminating in a point whereon it reſts; the upper part of the axis is firmly ſcrewed to the plate A, and turns in the collar D.

Fig. 7th.

E repreſents an endleſs ſcrew, which being turned on its axis, moves the plate A round its center; F a divided circular plate, which may be turned with or without turning the endleſs ſcrew; on the other end of the ſcrew arbor is a wheel (a) having its outer edge cut into teeth: X is a winch whereby the endleſs ſcrew is turned round.

Fig. 7th. 8th. and 9th.

G repreſents a triangular bar of ſteel, which paſſes over the circular plate A, and is firmly ſcrewed to the frame at H and I.

K a piece of ſteel whereon the ſcrew is intended to be cut, having its pivots formed in the manner before deſcribed, vid. p. 6th; on one end of this ſteel is a wheel L, having teeth round its circumference, which take into thoſe on the wheel (a) on the arbor of the endleſs ſcrew.

Fig. 7th. and 8th.

M and N repreſent two ſtrong pieces of braſs, in which the ſteel whereon the ſcrew is to be cut turns; they are firmly fixed to the triangular bar G by tightening the piece I by the ſcrews (n).

Fig. 7th. 8th. and 9th.

O is a piece of braſs which ſlides on the triangular bar G; its two extremities are made to fit the bar; it ſlides regularly thereon,

Fig. 8th.

and is prevented from riſing by the two ſpringing pieces (c c);

Fig. 7th.

near one end of the piece O is an angular groove (q) that holds the tool by which the threads are cut: as it was neceſſary to cut the ſcrew after the ſteel was hardened and tempered, there-

fore

fore the tool was pointed with a diamond: the cock (w) ſerves to faſten the tool, which may be ſet to take proper hold on the ſteel by turning the finger ſcrew (s) and is fixed there by the ſcrew (v). Fig. 7th, 8th, and 9th. Fig. 7th, and 9th.

To make a ſcrew perfect, it is only required to give the point which cuts the threads an uniform motion parallel to itſelf, and to the axis of the intended ſcrew, and that this motion be proportioned to the revolution of the intended ſcrew, as the number of threads may require.

To effect this a piece of thin tempered ſteel exactly of the ſame thickneſs throughout, is faſtened to the ſlide O at (r); the other end of the ſpring is faſtened to the pulley B, in the groove: now while the circle A with the pulley is turning round its center, by turning the endleſs ſcrew towards the right hand, the ſpring (t) draws the ſlide O with the cutter (q) along the triangular bar; at the ſame time the ſteel K, whereon the ſcrew is to be cut, is turned round its axis by the communication of the wheel (a) on the endleſs ſcrew with the wheel L. Fig. 7th.

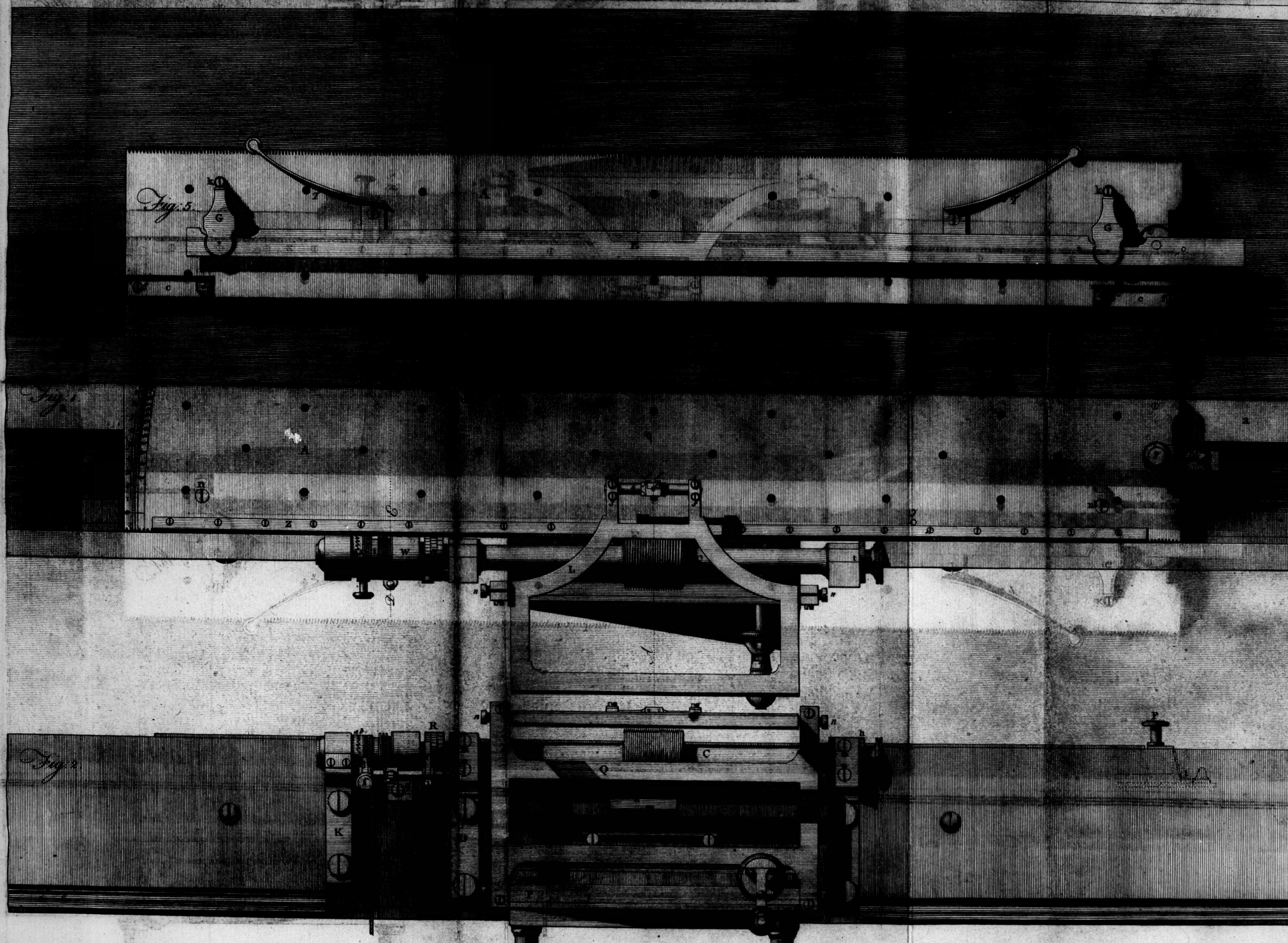
It hath already been mentioned that the ſcrew of the engine before deſcribed hath 20 threads in an inch; therefore, if the number of teeth on the wheel (a) be to the number on the wheel L, as the number of teeth on the wheel A is to the number of 20ths of an inch round the circumference of the pulley B, allowing for part of the thickneſs of the ſpring (t) the ſpaces between each of the threads of the ſcrew to be cut will be 20ths of an inch.

The ſize of the pulley was determined in this manner; the endleſs ſcrew being diſengaged from the wheel A, the ſlide O was drawn back till the end of it came nearly to the piece M; the endleſs ſcrew was again engaged in the wheel A; then

having two very ſmall dots on the ſlide O ſet off parallel to one ſide, and exactly five inches diſtant from each other, the ſlide was moved by turning the endleſs ſcrew, till one of the dots was biſected by a ſmall ſilver wire fixed acroſs a hole in a thin piece of braſs attached to the piece N; then the O on the divided wheel F was ſet to its index without moving the endleſs ſcrew, and the pulley was reduced, till 600 revolutions of the endleſs ſcrew brought the other dot to be exactly biſected by the fixed wire; theſe biſections were examined by a lens of half an inch focus ſet in a ſmall braſs tube, which was fixed perpendicularly over the wire.

THE END.

Plate I.



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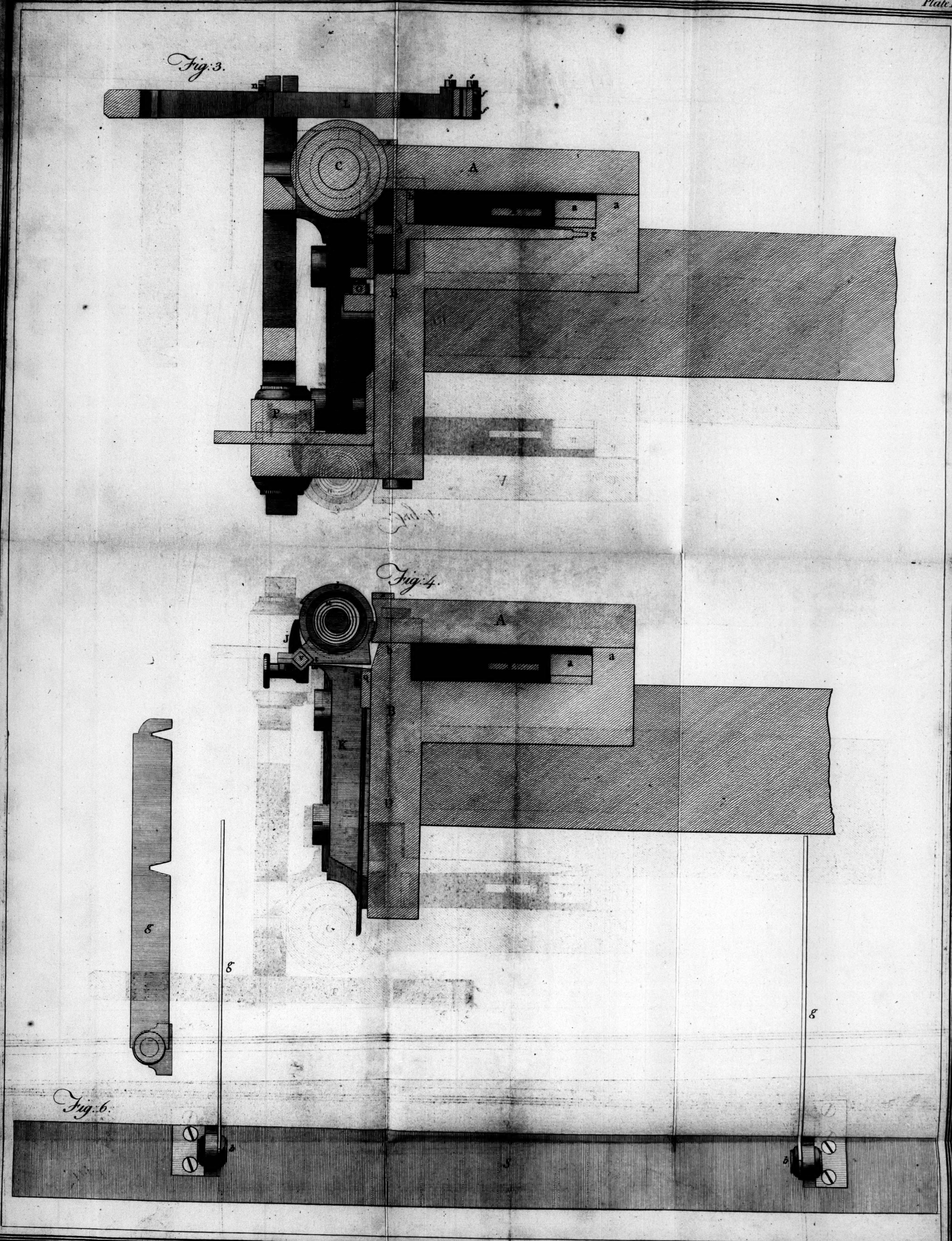

J. Ramsden Fecit.

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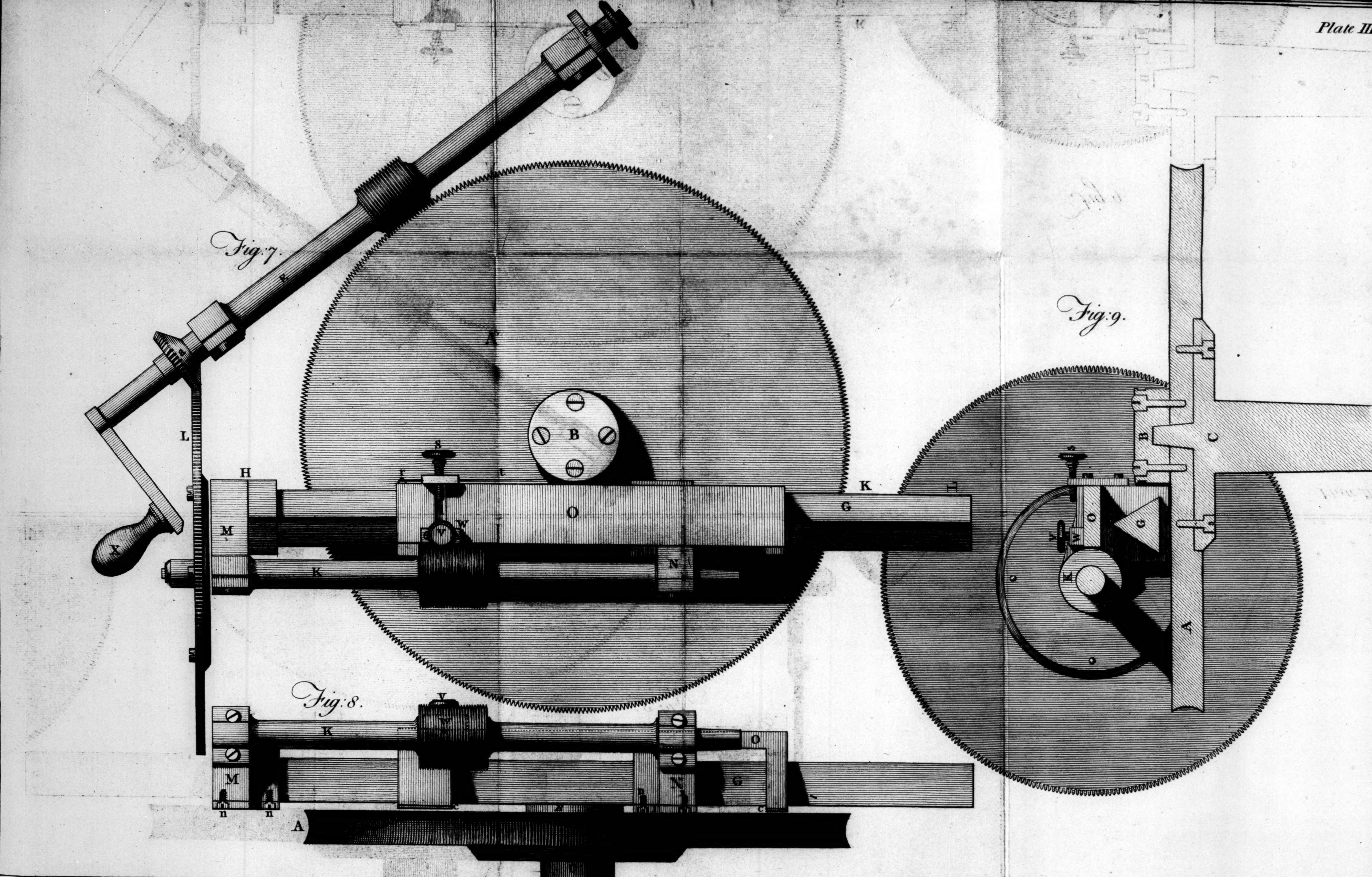
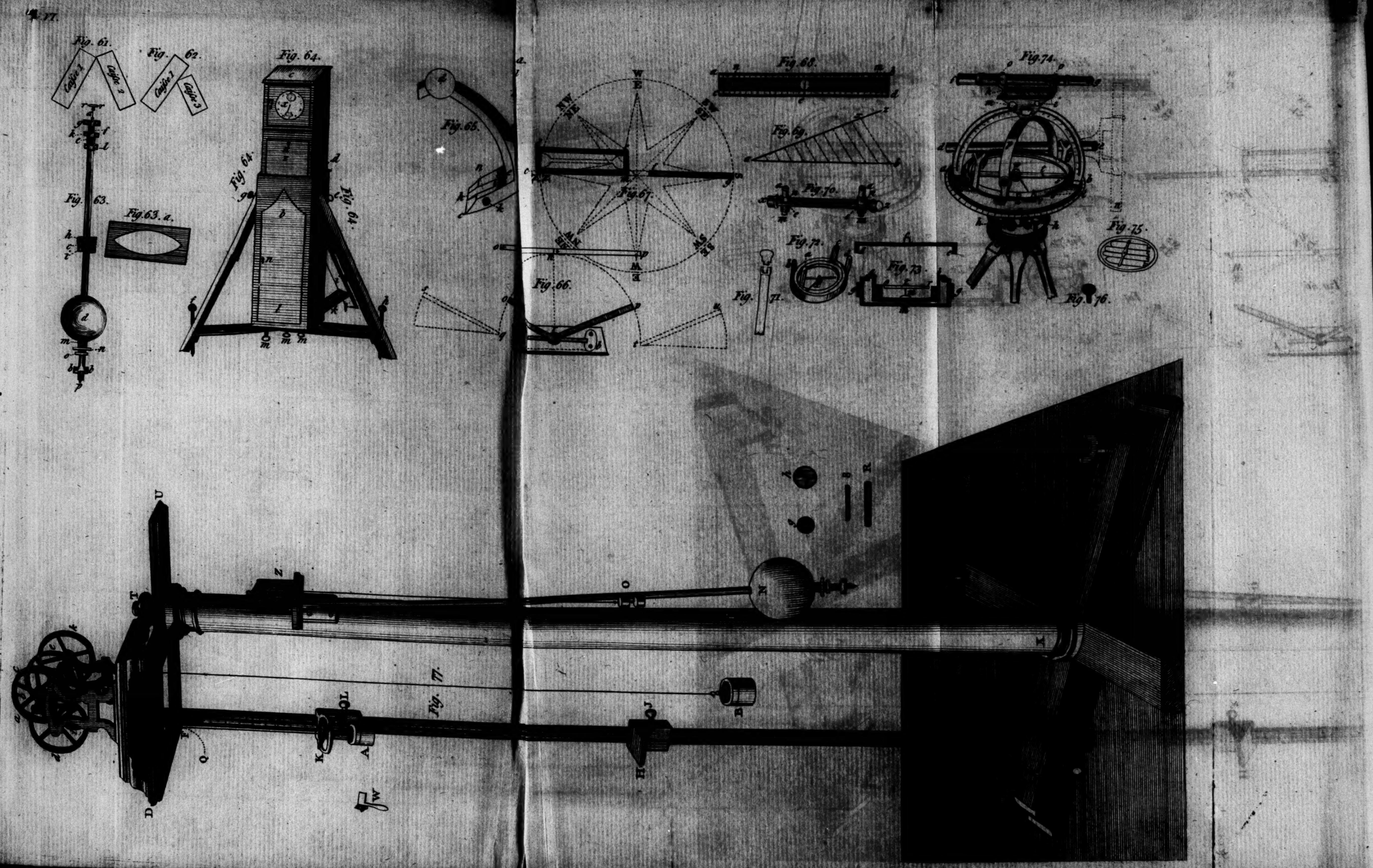


J. Ramsden Fecit. J. Basire sc.


17.
Fig. 61.
Caisse 1
Caisse 2
Fig. 62.
Caisse 2
Caisse 3
Fig. 63.
Fig. 63. a.
Fig. 64.
Fig. 65.
Fig. 66.
Fig. 67.
Fig. 68.
Fig. 69.
Fig. 70.
Fig. 71.
Fig. 72.
Fig. 73.
Fig. 74.
Fig. 75.
Fig. 76.
Fig. 77.